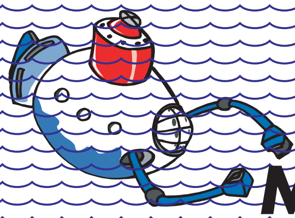

Monsters of the Deep

Focus
Predator-prey relationships between cold-seep communities and the surrounding deep-sea environment

Grade Level
7-8 Life Science

Focus Question
What deep-sea predators may visit cold-seep communities in search of food?

Learning Objectives
Students will be able to describe major features of cold seep communities, and list at least five organisms typical of these communities.

Students will be able to infer probable trophic relationships among organisms typical of cold-seep communities and the surrounding deep-sea environment.

Students will be able to describe the process of chemosynthesis in general terms, and will be able to contrast chemosynthesis and photosynthesis.

Students will be able to describe at least five deep-sea predator organisms.

Additional Information for Teachers of Deaf Students
In addition to the words listed as key words, the following words should be part of the vocabulary list.

Photosynthesis
Symbiosis
Hydrothermal vent
Hydrocarbon
Sediments
Polychaete worm
Bacteria
Symbiotic
Trophosome
Hemoglobin
Organic
Inferences

There are no formal signs in American Sign Language for any of these words listed as key words and many are difficult to lipread. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful. Make copies of the Background Information to use as handouts for students.

Materials
- ❒ 5 x 7 index cards
- ❒ Drawing materials
- ❒ Corkboard, flip chart, or large poster board

Audio/Visual Materials
None

Teaching Time
Two 45-minute class periods, plus time for individual group research

Seating Arrangement
Groups of four students

Maximum Number of Students
30

Key Words

Cold seeps
Methane hydrate ice
Chemosynthesis
Brine pool
Polychaete worms
Vestimentiferans
Chemosynthetic bacteria
Mussels
Sea stars
Eels
Squat lobsters
Snails
Isopods
Spider crabs
Anglerfishes
Pelican eel
Pancake bat fish
Viperfish
Fangtooth
Squids
Football fish
Hatchet fish
Trophic level

Background Information

One of the major scientific discoveries of the last 100 years is the presence of extensive deep sea communities that do not depend upon sunlight as their primary source of energy. Instead, these communities derive their energy from chemicals through a process called chemosynthesis (in contrast to photosynthesis in which sunlight is the basic energy source). Some chemosynthetic communities have been found near underwater volcanic hot springs called hydrothermal vents, which usually occur along ridges separating the earth's tectonic plates. Hydrogen sulfide is abundant in the water erupting from hydrothermal vents, and is used by chemosynthetic bacteria that are the base of the vent community food chain. These bacteria obtain energy by oxidizing hydrogen sulfide to sulfur:

$CO_2 + 4H_2S + O_2 > CH_2O + 4S + 3H_2O$

(carbon dioxide plus sulfur dioxide plus oxygen yields organic matter, sulfur, and water). Visit http://www.pmel.noaa.gov/vents/home.html for more information and activities on hydrothermal vent communities.

Other deep-sea chemosynthetic communities are found in areas where hydrocarbon gases (often methane and hydrogen sulfide) and oil seep out of sediments. These areas, known as cold seeps, are commonly found along continental margins, and (like hydrothermal vents) are home to many species of organisms that have not been found anywhere else on Earth. Typical features of communities that have been studied so far include mounds of frozen crystals of methane and water called methane hydrate ice, that are home to polychaete worms. Brine pools, containing water four times saltier than normal seawater, have also been found. Researchers often find dead fish floating in the brine pool, apparently killed by the high salinity.

As is the case with hydrothermal vents, chemosynthetic bacteria are also the base of the food chain in cold seep communities. Bacteria may form thick bacterial mats, or may live in close association with other organisms. One of the most conspicuous associations exists between chemosynthetic bacteria and large tubeworms that belong to the group Vestimentifera (formerly classified within the phylum Pogonophora; recently Pogonophora and Vestimentifera have been included in the phylum Annelida). Pogonophora means "beard bearing," and refers to the fact that many species in this phylum have one or more tentacles at their anterior end. Tentacles of vestimentiferans are bright red because they contain hemoglobin (like our own red blood cells). Vestimentiferans can grow to more than 10 feet long, sometimes in clusters of millions of individuals, and are believed to live for more than 100 years. They do not have a mouth, stomach, or gut. Instead, they have a large organ called a trophosome, that contains chemosynthetic bacteria. Hemoglobin in the tubeworm's blood absorbs hydrogen sulfide and oxygen from the water around the tentacles, and then transports these raw materials to bacteria living in the trophosome. The bacteria produce organic molecules that provide nutrition to the tubeworm. Similar relationships are found in clams and mussels that have chemosynthetic bacteria living in their gills. A variety of other organisms are also found in cold seep communities, and probably use tubeworms, mussels, and bacterial mats as sources of food. These include snails, eels, sea stars, crabs, isopods, sea cucumbers, and fishes. Specific relationships between these organisms have not been well-studied.

Cold-seep communities are surrounded by a much larger deep-sea environment that contains a variety of unusual creatures with names like viperfish, football fish, and vampire squid. Very little is known about interactions between cold-seep communities and organisms from the surrounding deep-sea. It seems likely, though, that deep-sea predators visit cold-seep communities in search of food, since these communities produce large amounts of biological material. The Ocean Exploration 2002 Gulf of Mexico Expedition includes a project to study the linkages between biological production in cold-seep communities and species in the surrounding deep-sea.

This activity focuses on cold-seep communities and deep-sea predators that may use these communities for food.

Learning Procedure

1. Lead a discussion of deep-sea chemosynthetic communities. Contrast chemosynthesis with photosynthesis. In both processes, organisms build sugars from carbon dioxide and water. This process requires energy; photosynthesizers obtain this energy from the sun, while chemosynthesizers obtain energy from chemical reactions. Point out that there are a variety of chemical reactions that can provide this kind of energy. Contrast hydrothermal vent communities with cold-seep communities. Visit http://www.bio.psu.edu/cold_seeps for a virtual tour of a cold seep community.
   Review the concepts of food webs, including the concept of trophic levels (primary producer, primary consumer, secondary consumer, and tertiary consumer).

2. Assign each student group one or more of the following groups to research:
   Cold-Seep Groups:
   Polychaete worms
   Vestimentiferans
   Chemosynthetic bacteria
   Mussels
   Sea stars

Eels
Squat lobsters
Snails
Isopods
Spider crabs

Deep-Sea Groups:
Anglerfishes
Pelican eel
Pancake bat fish
Viperfish
Fangtooth
Squids
Football fish
Hatchet fish

In addition to written reference materials (encyclopedia, periodicals, and books on the deep-sea), the following websites contain useful information:
http://www.bio.psu.edu/cold_seeps
http://www.europa.com/edge.of.CyberSpace/deep.html
http://www.europa.com/edge.of.CyberSpace/deep2.html
http://www.pbs.org/wgbh/nova.abyss/life.bestiary.html
http://biodidac.bio.uottawa.ca/
http://www.fishbase.org/search.cfm
Each student group should try to determine the energy (food) source(s) of their assigned organisms. It may not be possible to precisely determine specific foods for all groups, but students should be able to draw reasonable inferences from information about related organisms and anatomical features that may give clues about what the animals eat. Students should prepare a 5 x 7 index card for each organism with an illustration of the organism (photocopies from reference material, downloaded Internet pictures, or their own sketches), notes on where the organism is found, approximate size of the organism, and its trophic level (whether it is a primary producer, primary consumer, secondary consumer, or tertiary consumer).

3. Have each student group orally present their research results to the entire class. On a corkboard, flip chart, or piece of poster board, arrange the cards to show organisms that inhabit cold-seep communities, organisms from deep-sea environments outside cold-seep communities, and the trophic (feeding) relationships between these organisms. You may want to arrange the organisms by habitat first, then draw lines indicating which organisms probably provide an energy source (food) for other organisms. Painting tape or sticky notes can be used to temporarily anchor the cards until you have decided on the best arrangement, then tape or glue the cards in place.

4. Lead a discussion of the food web the students have created. Which groups show the greatest variety of anatomical types and feeding strategies? Which groups are responsible for primary production? What would the students infer about the relative abundance of each trophic level? In the simplest analysis, organisms at lower trophic levels (primary producers and primary consumers) must be more abundant than those on higher trophic levels. If this does not appear to be true, then there must be additional energy sources for the higher trophic levels (for example, deep-sea predators might be feeding in other areas besides the cold-seep communities).

The BRIDGE Connection

www.vims.edu/BRIDGE/ – Click on "Biology" in the navigation menu to the left, then "Plankton," then "Phytoplankton" for resources on ocean food webs. Click on "Ecology" then "Deep Sea" for resources on deep sea communities.

The "Me" Connection

Have students write a short essay on their favorite deep-sea or cold-seep community organism, stating why they like it and at least three interesting facts about it.

Connections to Other Subjects

English/Language Arts, Earth Science

Evaluation

Results and presentation of the research component of this activity provide a basis for group evaluation. In addition, individual written interpretations of the pooled results may be required prior to Step 4 to provide a means of individual assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Gulf of Mexico Expedition discoveries, and to find out what researchers are actually learning about interactions between cold-seep communities and the surrounding deep-sea environment.

Resources

http://oceanexplorer.noaa.gov – Follow the Gulf of Mexico Expedition daily as documentaries and discoveries are posted each day for your classroom use.

http://www.bio.psu.edu/People/Faculty/Fisher/fhome.htm – Web site for the principal investigator on the Gulf of Mexico expedition

http://www.rps.psu.edu/deep/ – Notes from another expedition exploring deep-sea communities

http://ridge2000.bio.psu.edu/nonsciencelinks.htm – Links to other deep ocean exploration web sites

http://www-ocean.tamu.edu/education/oceanworld/resources/ – Links to other ocean-related web sites

Paull, C.K., B. Hecker, C. Commeau, R.P. Feeman-Lynde, C. Nuemann, W.P. Corso, G. Golubic, J. Hook, E. Sikes, and J. Curray. 1984. Biological communities at Florida Escarpment resemble hydrothermal vent communities. Science 226:965-967 – early report on cold seep communities.

National Science Education Standards

Content Standard A: Science As Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science
- Transfer of energy

Content Standard C: Life Science
- Structure and function in living systems
- Populations and ecosystems

Activity developed by Mel Goodwin, PhD, The Harmony Project, Charleston, SC

Notes/Thoughts/Inspirations